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Interaction between molten blister copper and 316L stainless steel

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ABSTRACT

Blister copper is cast and usually processed further. At the Tsumeb Custom Smelter, Namibia, it is blown with nitrogen from mild steel lances, but these lances do not last long, causing down-time and reduced copper throughput. Additionally, the blister copper purity should be at least 98.5 wt% Cu, else the price is compromised. Thus, keeping contamination to a minimum and reducing down-time are very important.

It was thought that stainless steel lances might last longer than those of mild steel, and since this could not be attempted at the smelter, a simple experiment was undertaken to identify any reactions between the molten copper and the stainless steel. The action of the lance was simulated by using agitation by nitrogen, and the molten copper was poured into stainless steel crucibles, rather than manufacturing lances.

XRF measurements were done on a wave length dispersive Philips PW2404.

Blister copper was melted at 1200°C in 316L stainless steel crucibles held at different times under the following conditions: in inert conditions without agitation, in inert conditions with agitation by nitrogen (600kPa pressure and 10 $L.min^{-1}$ flow-rate), and in oxidizing conditions (500kPa and 21 min^{-1}) with nitrogen agitation. Coke was placed on top of the melt to prevent oxidation. After the specified times, the copper was poured out. Sections were cut through the crucibles and copper remnants, prepared metallographically, and studied using SEM with EDX. Spot analyses were taken across the interface from the blister copper matrix to the steel. X-ray maps were also undertaken across the interface.

For 40 minutes in inert conditions without agitation, the interface was up to ~80μm wide. It comprised different discrete phases in the copper-rich matrix. Further from the steel was a very light two-phase mixture: overall: ~86 Cu, ~2 Fe, ~10 C with less than 1 Cr and Ni (wt%), deduced as (Cu) + graphite. Nearer the steel was a darker phase, ~67 Cu, ~20 Fe, ~7 C, ~3 Cr and less that 1 Ni (wt%), deduced as (Fe). The matrix had only ~85 wt% Cu.

After 80 minutes in the same conditions, some of the copper had diffused along the grain boundaries of the steel, and the interface was ~150μm. The very light phase mixture had nearly disappeared and there was much more porosity.

Under oxygen, there was much slag, of composition: ~10 Cu, ~44 Fe, ~12 Ni, ~2 Cr and ~27 O (wt%), with the copper only having ~96 wt%, purity, i.e. below the accepted limit. This copper could not be poured freely from the crucible because of the high slag content.

There is a liquid miscibility gap across most of the C-Cu-Fe system, which gave the two different regions in the interface. There is also a miscibility gap in the fcc solid solution, which gives the two different phases, (Fe) and (Cu) near the steel.

The 316L stainless steel crucibles contaminated the copper. Under industrial conditions, and longer times, the effects would be worse, and any 316L lances would deteriorate fast. Since the liquid miscibility gap occurs very near 100% Cu, it would be better to avoid any ferrous material, and instead use refractory linings, which are used for the larger vessels, which would also reduce diffusion.